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By Howard Freiberger

It would hardly be possible for me to consider in any detail the many fine researches being pursued throughout the world in sensory aids for the blind. Even a brief cataloging of the work in the United States sponsored by the Government forms an extensive document appearing elsewhere in this issue of BLINDNESS. By mentioning some of the work I shall try to convey an impression as to what one would most likely find if he were to ferret out each individual worker and each separate project.

The reader who needs greater detail and who wishes to do some independent study of source materials will find the Catalog Appendix (1) as well as the first three volumes of the same set quite useful. The reprint edition of Paul A. Zahl's BLINDNESS (2) with an updated bibliography current to 1962 should also lead a reader to much information. A classified annotated bibliography on 3 x 5 inch file cards, kept current by supplements, is the work of Miss Isabella S. Diamond of the AAWB staff with sponsorship of VRA. Distributed to certain reference centers throughout the country, and available for individual purchase, this system also contains a wealth of data. The Research Bulletin (3) of American Foundation for the Blind contains original and reprint articles very useful to the sensory aids researcher. Briefs on results of Veterans Administration sensory aids research are carried in the semi-annual Bulletin of Prosthetics Research (4).

The reader desiring to "dig deeper" should not overlook the vast amounts of information contained in the closely printed columns of United States and foreign patents. Four patents (10), (19), (22), (23), are included in this paper's references by way of example and to supplement the text. The proceedings of the invitational International Conference on Sensory Devices for the Blind held June 13-17, 1966 by St. Dunstan's, London, England, should provide additional up-to-the-minute facts.

Two Broad Avenues to Solution Open

I should now like to indulge in some categorizing to introduce the reader to the many-faceted interdisciplinary activities which currently engage the sensory-aids researcher. As with any other problems facing mankind there are open to us two broad avenues to solution of the problems of blindness—a direct approach with relatively frontal attack, and an indirect approach using tactics of circumvention. By the direct approach I refer to the most elegant, though difficult to achieve solution, some form of true "artificial vision," wherein a straight-forward attempt would be made to replace with a functioning man-made prosthesis those parts of the visual system whose dysfunction

causes the blindness. At best such a system would restore vision essentially to normal. More realistic goals at first may be restoration of only some coarser form of vision or light perception, but relying on a light receiving "end organ" capable of transmitting sensed optical information to appropriate central nervous system points. These ideas have intrigued men for a long time, but to date only rudimentary experiments have been made, and in your author's view both the biological and engineering problems posed by this approach are most formidable. In another paper in this issue of "BLINDNESS" Prof. George G. Mallinson considers this direct approach in greater detail.

By the indirect approach I refer to the efforts to provide some substitute for a non-functioning visual system but by means which circumvent the awesome difficulties of directly feeding visual information to the visual centers of the brain. Such means generally make use of remaining sensory systems, hearing and touch for a blind person, and touch alone for one who is deaf-blind.

The Rev. Thomas J. Carroll in the book "BLINDNESS" (5) analyzes the losses resulting from blindness in considerable depth. In addition to psychological, aesthetic, vocational, financial and personality factors, he holds losses in basic skills such as mobility, and losses in communication capabilities such as reading to be important. It is to counter these latter two losses that much recent technological sensory aids research has been undertaken. Mobility devices, travel aids, obstacle detectors, path-finders, optar, midar, ensor, amauroskop, elektroftalm are but a few of the terms used in naming mobility aids. Similarly with reading machines one hears terms such as optophone, visotoner, visagraph, colineator, visotactor, recognition machine, optotact, etc.

Mobility devices may be broadly classified into active and passive types. The active systems emit some form of energy which interacts with the environment and, upon selective reflection therefrom, carries back information about the surroundings to the instrument's receiver. Passive systems do not "illuminate" the environment with emitted energy, but are responsive to existing ambient conditions. Both systems have their engineering advantages and disadvantages and at this time it is not at all clear that one is outstandingly superior to the other.

Another parameter, long familiar to radar, optical, and sonar engineers, relates to the type of coverage of the environment the system provides. Some systems have narrow beams with which to examine the environment. They must usually be scanned over the surroundings to obtain adequate quantities of information. Systems with wide beams require less scanning, but if active, may require more energy, and may yield less detailed information. It must be emphasized that the amount of energy needed by a system is a limiting factor in practical design because the energy source usually must be carried by the user and should allow for an operating endurance of at least a normal day's use.

Vision is a sense which makes use of the electromagnetic energy known as light, and because light travels so nicely through so many media, vision provides information about things at a distance from the observer. One will find that most mobility systems proposed also rely on some physical phenomenon capable of action-at-a-distance. Instruments have been proposed and often built which employ visible light, infrared or ultraviolet light, radio waves, sound, and the electrostatic field to get their capability to probe into space around

them. Much information in these areas may be found in (1) and in the Proceedings of the Rotterdam Mobility Research Conference (6).

The work at Bionic Instruments, Inc., Bala-Cynwyd, Pennsylvania, sponsored by the Veterans Administration, is an example of current-day efforts to produce a multi-beam, narrow-beam width, injection laser light, mobility aid for the blind, housed in a specially designed cane (4), (7). Experience over the years has led designers of such instruments to the conclusion that the advantages over an ordinary long cane are in the areas of early warning, protection in the head and shoulders region, and more information about the environment which usually connotes better orientation capabilities for a blind person. This electronic-optical cane "looks" upward to the region about six feet ahead of the user and at head level to provide warning of overhanging or protruding objects. It "looks" ahead for early warning of objects in the path (or absence thereof indicating a clear path). The third beam scans the terrain, the aim here being to give ample warning of discontinuities such as drop-offs or rises. The cane shaft can simultaneously be used in a more or less conventional way to provide information by direct contact with the environment.

Inventor Inspired By Blind Bats

An example of a modern mobility aid using sound energy to probe the environment is the ultrasonic aid for the blind marketed for experimental trials by Ultra Electronics, Limited, London, England (8), (9), (10). One successful trial user of this device, Fred Gissoni, has already published some comments (11). This 10 oz. hand-held, flashlight-like aid directs pulses of inaudible swept-frequency ultrasonic energy to the environment being probed. Reflected ultrasound is converted in the receiver section of the unit to an audible signal which through an earpiece gives the user information as to the range and texture of objects scanned. The amazing performances of certain blind bats (12), (13) known to use pulsed ultrasonic energy in their "guidance system," no doubt inspired the inventor of this ultrasonic aid.

Before I leave the subject of mobility aids, I should like to point out that there are three more-or-less distinct levels to the mobility problem, and that consideration of the man-aid-environment system is essential to productive results in the travel aid area. Closest to a blind person is his very immediate environment, and he must avoid (or find) items here as he moves from place to place. A wine glass on a table is perhaps an extreme example, but in taking even a few steps in a room, chairs, tables and cabinets often interfere with clear passage. A second level is one of orientation in the local space. Just where in a room am I, where are the door(s) and window(s); when I depart which way shall I go? A third level is akin to navigational position fixing. Where in the city, along a country lane, in a field, or on a transit system am I? While conventional mobility means and practices of blind people supply much information regarding the environment at all three levels mentioned above, we look to the future when a true mobility aid may begin to approach the level of helpfulness achievable today only with a sighted guide.

The problem of reading for the blind also has been attacked frontally by those who develop systems designed to actually "read" the printed characters on a page and convey their information to a blind person. "Back-door" approaches which avoid direct reliance on print include not only traditional specially prepared materials such as braille and recorded books, wherein a

sighted reader takes some part in the process, but also more recently developed experimental systems making use of the wealth of material perforated into Teletypesetter or Monotype tapes, readily machine readable (14), and reasonably suitable for non-human input to braille making (15) and possibly spoken word reproducing systems (16).

Systems involving various combinations of automated and human services, usually involving some central master facility connected to the blind person's home or location by the regular telephone lines have also been described (17). One variant would have a scanning attachment in the blind users location to receive printed or written matter, transmit it to the central location where it would be read back to the subscriber over the telephone by an impersonal operator. Such a system was demonstrated by David H. Shepard at the Sixth Reading Machine Conference.

Hearing and Touch Generally Unimpaired

A sampling of much recent thought regarding reading machines for the blind may be found in the minutes of the conferences held from time to time since 1954 by the Veterans Administration, the sixth and most recent having been held at Washington, D.C., January 27-28, 1966 (17).

Because the senses of hearing and touch are generally unimpaired in a blind person, classes of reading machines have developed having audible or tactile outputs. Some blind people also are deaf, others, particularly as they age, have hearing losses, and some, possibly because of burns, chemical accident, or neurological lesion, have poor touch sensation in their finger tips. Sensory dysfunctions, impairing one or more of any of our principal information channels with the outside world. suggest why aids must be available with outputs matching the remaining capabilities of the individual.

Reading machines have been classified as being "direct translation" (18), (19), "intermediate" (20), or "character recognition" (21) types. The direct translation machines are usually the simplest to construct. They only translate directly the graphic letter-shape information on a page to some audible or tactile rendition, a process involving very little machine processing of information, storage, or logic functions.

The intermediate machine does somewhat more processing, and may recognize certain letter features as projections below the line as in "g", "j", "p", "q", and "y". It does not, however, identify each letter, a procedure accomplished in the recognition machine, the most complex device of all. Assuming optimum development of all of these classes of machines, and this happy state of affairs has by no means been reached, it is quite likely that the simplest physical construction, the direct translation type, will require the greatest user stress in operation, while the complex recognition machine will permit much more relaxed reading.

The work at Mauch Laboratories, Dayton, Ohio, on the "Visotoner" (21) is an example of current research efforts to produce a small, portable, optical-to-sound, direct translation reading machine for the blind. This unit is battery driven, accommodates to most conventional print sizes, and produces tone combinations from a bank of nine tone generators dependent on letter shapes being scanned. Reading speeds with such an instrument are

expected to be slow, some persons reading only five words per minute after some training, though exceptional readers with instruments of this general optophone class have reported speeds ten times as high for short passages of certain materials.

Mauch Laboratories is also working to improve their "Visotactor," a small direct translation device with tactile output. Work on a direct translation tactile device has also been reported by Linvill and Bliss (22). Their system, simulated in part through use of a computer, has resulted in some encouraging reading rates.

The intermediate reading machine seems to attract fewer researchers than either of the other types. Patrick W. Nye (17), (20), has reported some careful comparisons with other systems and analyses of this system, and as one would surmise, the results are somewhat better than those obtained with the simpler optophone, and are inferior to results predicted for recognition types.

A first experimental prototype of a complete recognition reading machine system for the blind was completed at Mauch Laboratories in 1965 (17), (21). This unit comprises an adjustable optical system which focuses an image of the print on the page onto a specially designed photocell array. As the letter image passes over the cells, up to five "snapshots" or interrogations of cell condition (dark or light) may be made. This information is decoded in a diode matrix designed to identify upper and lower case letters and certain printing ligatures. Once identified, the letter information is passed to the word synthesizer (23), a device which can group the individual letters into a word-group, and then utter in close succession the sounds of the word-group in Metfessel's spelled-speech (24). One thus hears what is on the page in a sort of coalescing spelling which Professor Metfessel feels can convey information at 60-90 words per minute after relatively brief training with the system. As of this writing the whole system has been demonstrated under laboratory conditions with carefully tracked typewritten materials at speeds of around 30 words per minute.

In conclusion, I should like to emphasize that the sensory aids for the blind which we have been discussing are, by definition, simultaneously aids for all human beings. Now human beings are often loath to use devices or engage in practices where the very act of so doing takes more out of them than they are able to derive in benefits or satisfactions. Similarly, most reject courses which mark them as too different from their fellow humans. It is my belief that these human traits have conspired against the introduction of so many of the sensory aids, carefully built, patented and promoted by hopeful inventors over the years gone by. Looking with confidence to the not-too-distant future, however, it is felt that increasing awareness by engineers and physical scientists of behavioristic concepts, and their every increasing technological capabilities allowing for man-made constructions rivalling nature herself in areas of size, weight, complexity and power requirements, will certainly lead to some exciting new sensory aids.

FOOTNOTES

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